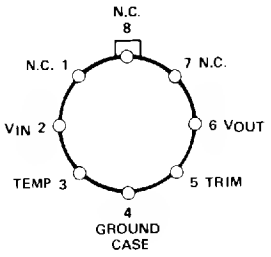
+5V Precision Voltage Reference (Guaranteed Long-Term Stability)

REF-05

FEATURES

- **5 Volt Output**
- **Guaranteed Long-Term Stability ..... 100ppm/1000 Hrs Max**
- **Excellent Temperature Stability ..... 8.5ppm/°C Max**
- **Low Noise ..... $15\mu V_{p-p}$ Max**
- **Low Supply Current ..... 1.4mA Max**
- **Wide Input Voltage Range ..... 7V to 40V**
- **High Load-Driving Capability 20mA**
- **Short-Circuit Proof**
- **Processed Per MIL-STD-883**

PIN CONNECTIONS & ORDERING INFORMATION

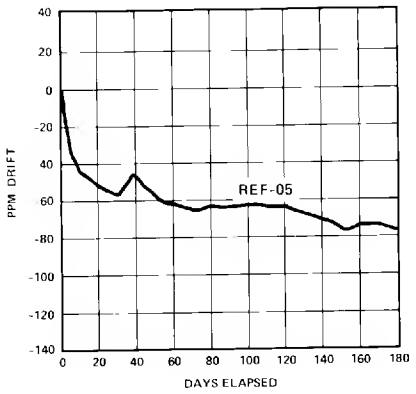


TO-99 (J-Suffix)
REF-05AJ/883
REF-05BJ/883

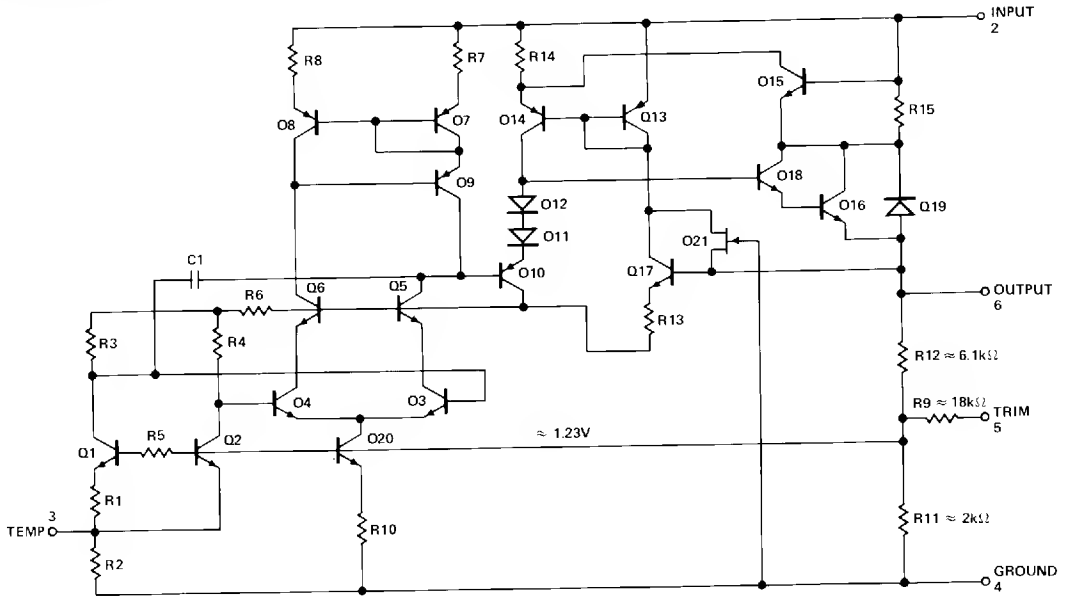
GENERAL DESCRIPTION

The REF-05 precision voltage reference provides a stable +5V output which can be adjusted over a ±6% range with minimal effect on temperature stability. Long-term drift is guaranteed at 100ppm/1000 hrs. maximum. Single-supply operation over an input voltage range of 7V to 40V, low current drain of 1mA, and excellent temperature stability are achieved with an improved bandgap design. Low cost, low noise, and low power make the REF-05 an excellent choice whenever a stable voltage reference is required. Applications include D/A and A/D converters, portable instrumentation, and digital voltmeters. The versatility of the REF-05 is enhanced by its use as a monolithic temperature transducer. For +10V Precision Voltage References see the REF-10 data sheet.

LONG-TERM DRIFT PLOT (Average of 20 Devices)



SIMPLIFIED SCHEMATIC



REV. B

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 617/329-4700 Fax: 617/326-8703 Twx: 710/394-6577
Telex: 924491 Cable: ANALOG NORWOODMASS

ABSOLUTE MAXIMUM RATINGS (Note 1)

Input Voltage
REF-05A, B 40V
Output Short-Circuit Duration
(to Ground or V_{IN}) ..... Indefinite
Storage Temperature Range ..... −65°C to +150°C
Lead Temperature (Soldering, 60 sec) ..... +300°C

Operating Temperature Range
REF-05A, REF-05B ..... −55°C to +125°C

PACKAGE TYPE	Θ_{jA} (NOTE 2)	Θ_{jC}	UNITS
TO-99 (J)	170	24	°C/W

NOTES:
1. Derate at 7.1mW/°C above 80°C ambient temperature for TO-99 (J) package.
2. Θ_{jA} is specified for worst case mounting conditions, i.e., Θ_{jA} is specified for device in socket for TO package.

ELECTRICAL CHARACTERISTICS at $V_{IN} = +15V$, $T_A = 25°C$, unless otherwise noted.

			REF-05A			REF-05B			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Output Voltage	V_O	$I_L = 0$	4.985	5.0	5.015	4.975	5.0	5.025	V
Output Adjustment Range	ΔV_{trim}	$R_P = 10k\Omega$	±3	±6	—	±3	±6	—	%
Output Voltage Noise	e_{np-p}	0.1Hz to 10Hz (Note 1)	—	10	15	—	10	15	μV_{p-p}
Long-Term Stability		(Note 1)	—	65	100	—	65	100	ppm/1kHrs
Line Regulation (Note 2)		$V_{IN} = 8V$ to 33V	—	0.006	0.010	—	0.006	0.010	%/V
Load Regulation (Note 2)		$I_L = 0$ to 10mA	—	0.005	0.010	—	0.006	0.010	%/mA
Turn-On Settling Time	t_{on}	To ±0.1% of final value	—	5	—	—	5	—	μs
Quiescent Supply Current	I_{SY}	No Load	—	1	1.4	—	1	1.4	mA
Load Current	I_L		10	21	—	10	21	—	mA
Sink Current	I_S	(Note 7)	−0.3	−0.5	—	−0.3	−0.5	—	mA
Short-Circuit Current	I_{SC}	$V_O = 0$	15	30	60	15	30	60	mA
Temperature Voltage Output	V_T	(Note 3)	—	630	—	—	630	—	mV

ELECTRICAL CHARACTERISTICS at $V_{IN} = +15V$, $-55°C \le T_A \le +125°C$ and $I_L = 0mA$, unless otherwise noted.

			REF-05A			REF-05B			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Output Voltage Change with Temperature (Notes 4 & 5)	ΔV_{OT}	$-55°C \le T_A \le +125°C$	—	0.06	0.15	—	0.18	0.45	%
Output Voltage Temperature Coefficient	TCV_O	(Note 6)	—	3	8.5	—	10	25	ppm/°C
Change in V_O Temperature Coefficient with Output Adjustment		$R_P = 10k\Omega$	—	0.7	—	—	0.7	—	ppm/%
Line Regulation ($V_{IN} = 8V$ to 33V) (Note 2)		$-55°C \le T_A \le +125°C$	—	0.009	0.015	—	0.009	0.015	%/V
Load Regulation ($I_L = 0$ to 8mA) (Note 2)		$-55°C \le T_A \le +125°C$	—	0.007	0.012	—	0.009	0.015	%/mA
Temperature Voltage Output Temperature Coefficient	TCV_T	(Note 3)	—	2.1	—	—	2.1	—	mV/°C
Quiescent Supply Current	I_{SY}	No Load	—	1.6	2.0	—	1.6	2.0	mA

NOTES:
1. Sample tested. Long-term stability is tested with power applied continuously.
2. Line and Load Regulation specifications include the effect of self heating.
3. Limit current in or out of pin 3 to 50nA and capacitance on pin 3 to 30pF.
4. ΔV_{OT} is defined as the absolute difference between the maximum output voltage and the minimum output voltage over the specified temperature range expressed as a percentage of 5V.

$$\Delta V_{OT} = \left|\frac{V_{MAX} - V_{MIN}}{5V}\right| \times 100$$

5. ΔV_{OT} specification applied trimmed to +5V or untrimmed.
6. TCV_O is defined as ΔV_{OT} divided by the temperature range, i.e.,

$$TCV_O = \frac{\Delta V_{OT}}{180°C}$$

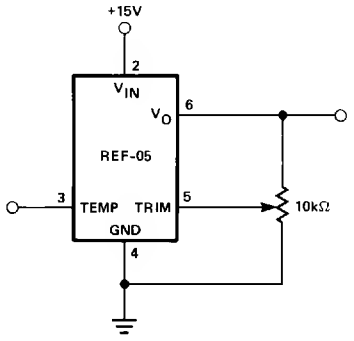
7. During sink current test the device meets the output voltage specified.

OUTPUT ADJUSTMENT

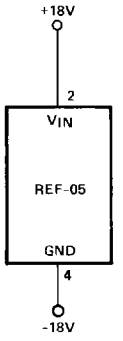
The REF-05 trim terminal can be used to adjust the output voltage over a 5V ±300mV range. This feature allows the system designer to trim system errors by setting the reference to a voltage other than 5V. Of course, the output can also be set to exactly 5V or to 5.12V for binary applications.

Adjustment of the output does not significantly affect the temperature performance of the device. Typically the temperature coefficient change is 0.7ppm/°C for 100mV of output adjustment.

OUTPUT ADJUSTMENT CIRCUIT

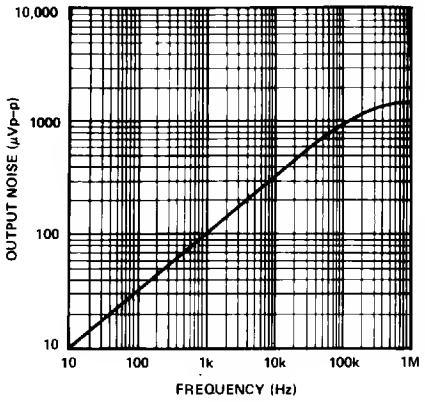


BURN-IN CIRCUIT

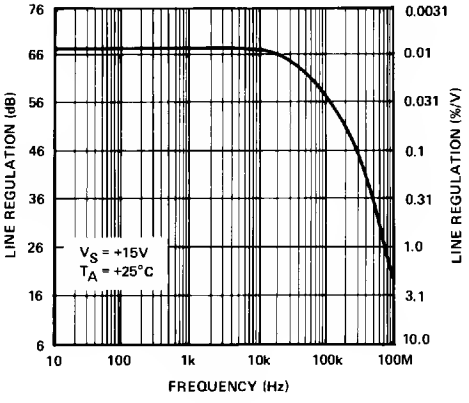


TYPICAL PERFORMANCE CHARACTERISTICS

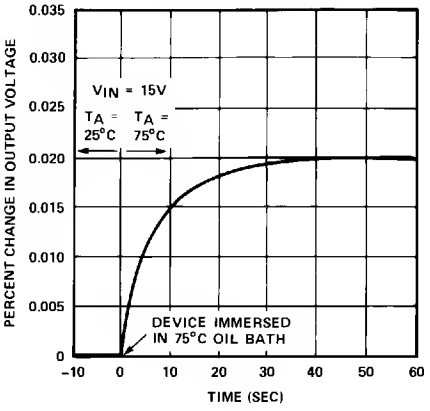
OUTPUT WIDEBAND NOISE vs BANDWIDTH (0.1Hz TO FREQUENCY INDICATED)



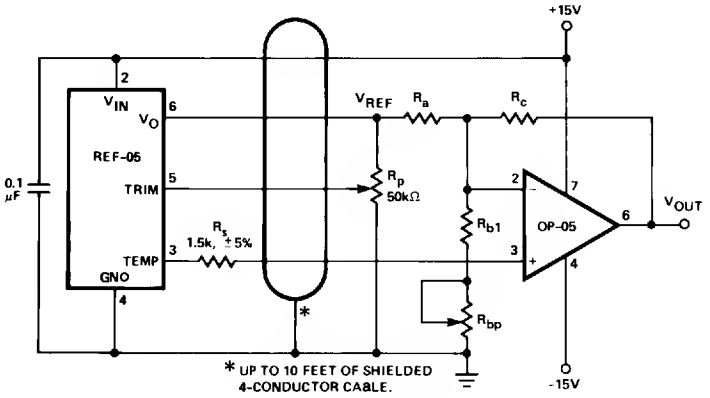
LINE REGULATION vs FREQUENCY



OUTPUT CHANGE DUE TO THERMAL SHOCK



PRECISION TEMPERATURE TRANSDUCER WITH REMOTE SENSOR

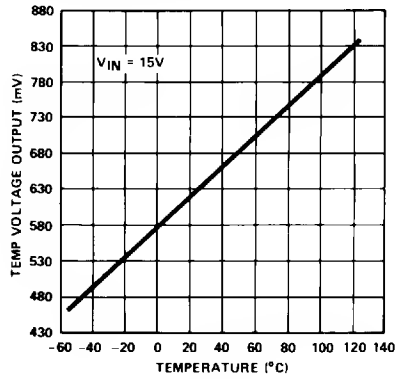


RESISTOR VALUES

TCV_{OUT} SLOPE (S)	10mV/°C	100mV/°C	10mV/°F
TEMPERATURE RANGE	−55°C to +125°C	−55°C to +125°C	−67°F to +257°F
OUTPUT VOLTAGE* RANGE	−0.55V to +1.25V	−5.5V to +12.5V	−0.67V to +2.57V
ZERO-SCALE	0V @ 0°C	0V @ 0°C	0V @ 0°F
R_a (±1% resistor)	9.09kΩ	15kΩ	7.5kΩ
R_{b1} (±1% resistor)	1.5kΩ	1.82kΩ	1.21kΩ
R_{bp} (Potentiometer)	200Ω	500Ω	200Ω
R_c (±1% resistor)	5.11kΩ	84.5kΩ	8.25kΩ

*For 125°C operation, the op amp output must be able to swing to +12.5V; increase V_{IN} to +18V from +15V if necessary.

TYPICAL TEMPERATURE VOLTAGE OUTPUT vs TEMPERATURE (REF-05A)

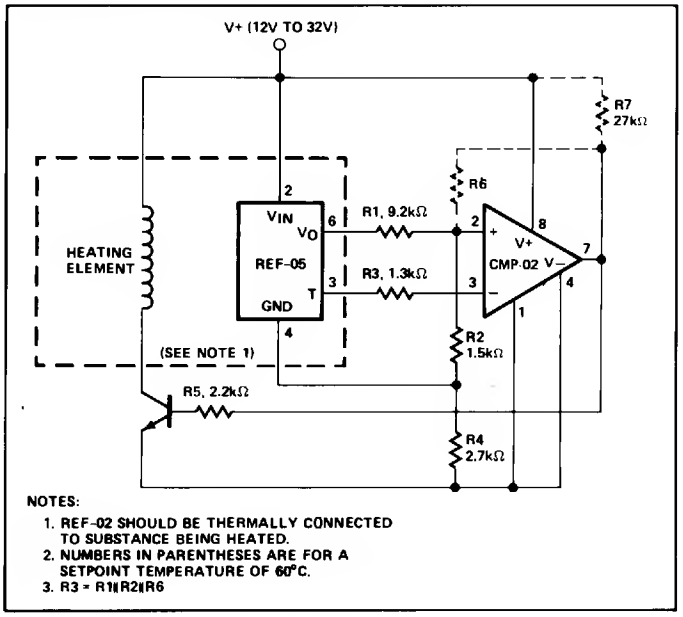


REFERENCE STACK WITH EXCELLENT LINE REGULATION

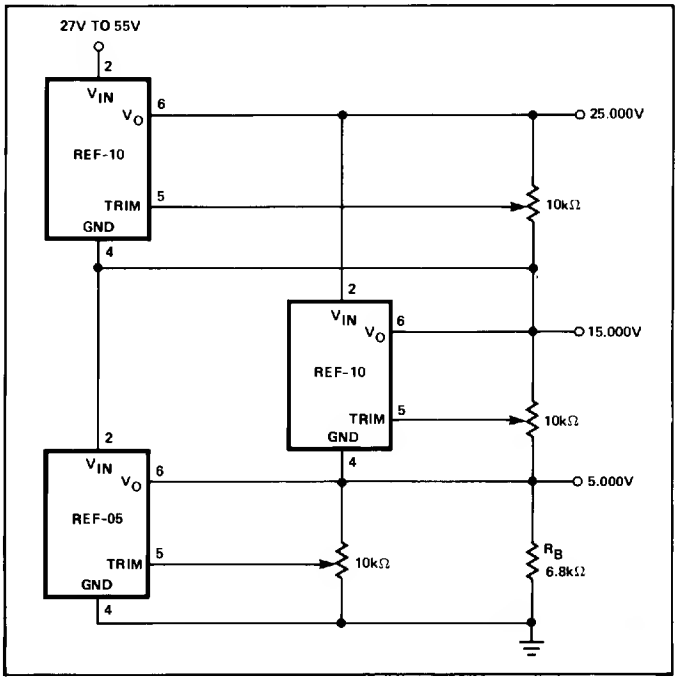
Two REF-10's and one REF-05 can be stacked to yield 5V, 15V and 25V outputs. An additional advantage is near-perfect line regulation of the 5V and 15V outputs. A 27V to 55V input change produces an output change which is less than the noise voltage of the devices. A load bypass resistor (R_g) provides a path for the supply current (I_{SY}) of the 15V regulator.

In general, any number of REF-10's and REF-05's can be stacked this way. For example, ten devices will yield ten outputs in 5V or 10V steps. The line voltage can range from 100V to 130V, however, care must be taken to ensure that the total load currents do not exceed the maximum usable current (typically 21mA).

TEMPERATURE CONTROLLER

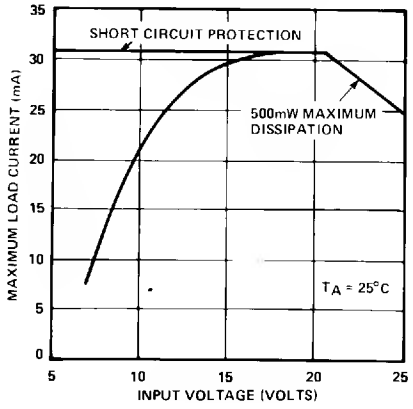


NOTES:
1. REF-02 SHOULD BE THERMALLY CONNECTED TO SUBSTANCE BEING HEATED.
2. NUMBERS IN PARENTHESES ARE FOR A SETPOINT TEMPERATURE OF 60°C.
3. R3 = R1‖R2‖R6

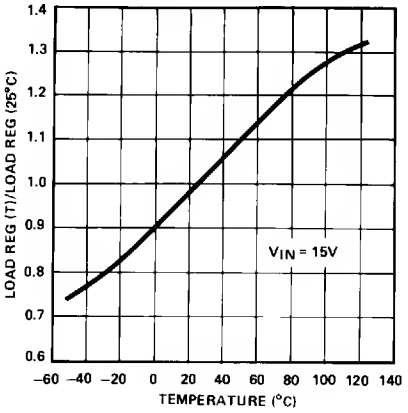


TYPICAL PERFORMANCE CHARACTERISTICS

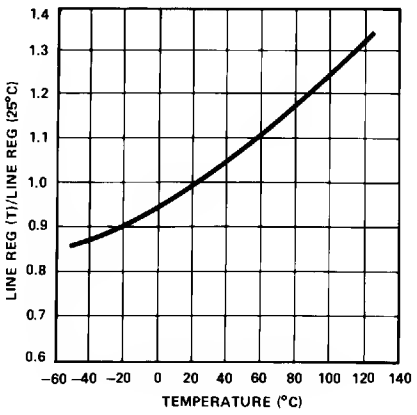
MAXIMUM LOAD CURRENT vs INPUT VOLTAGE



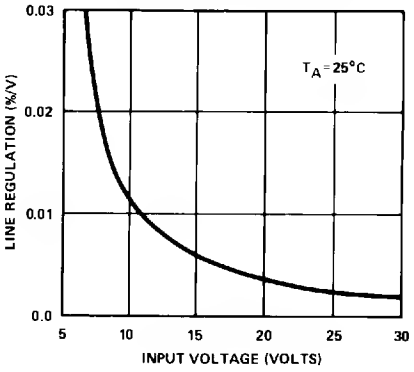
NORMALIZED LOAD REGULATION (ΔI_L = 10mA) vs TEMPERATURE



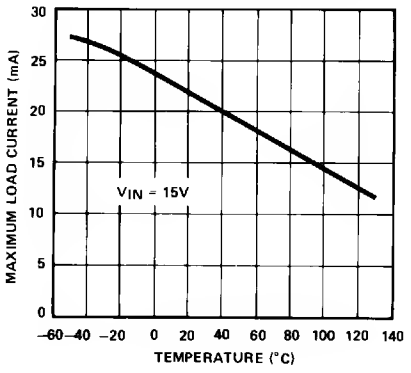
NORMALIZED LINE REGULATION vs TEMPERATURE



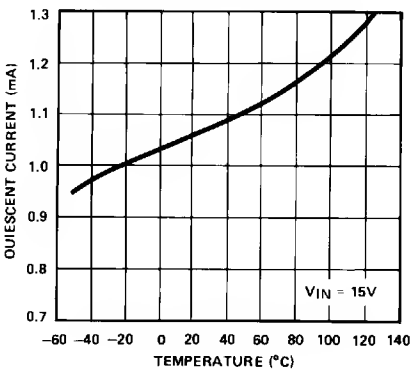
LINE REGULATION vs SUPPLY VOLTAGE



MAXIMUM LOAD CURRENT vs TEMPERATURE

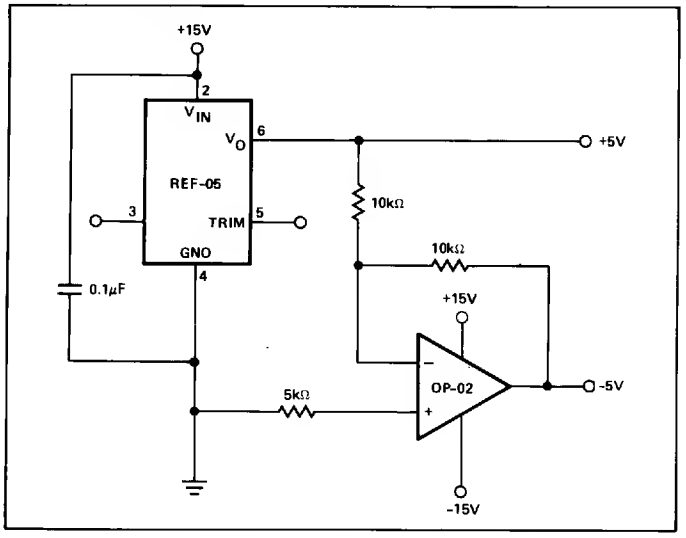


QUIESCENT CURRENT vs TEMPERATURE

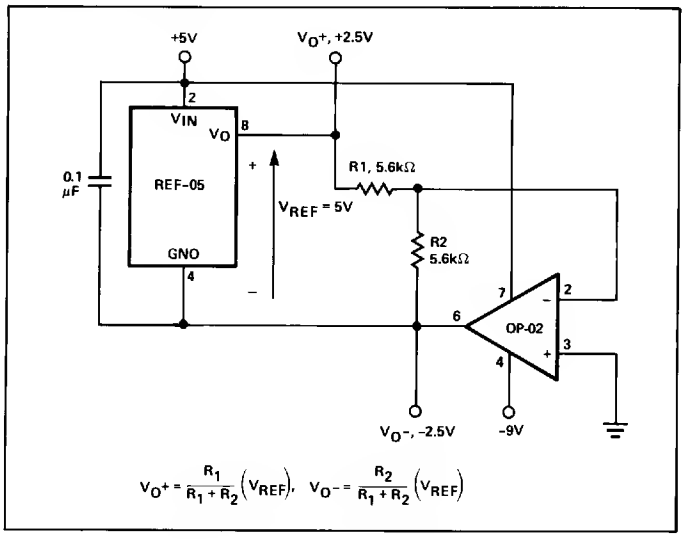


TYPICAL APPLICATIONS

±5V REFERENCE



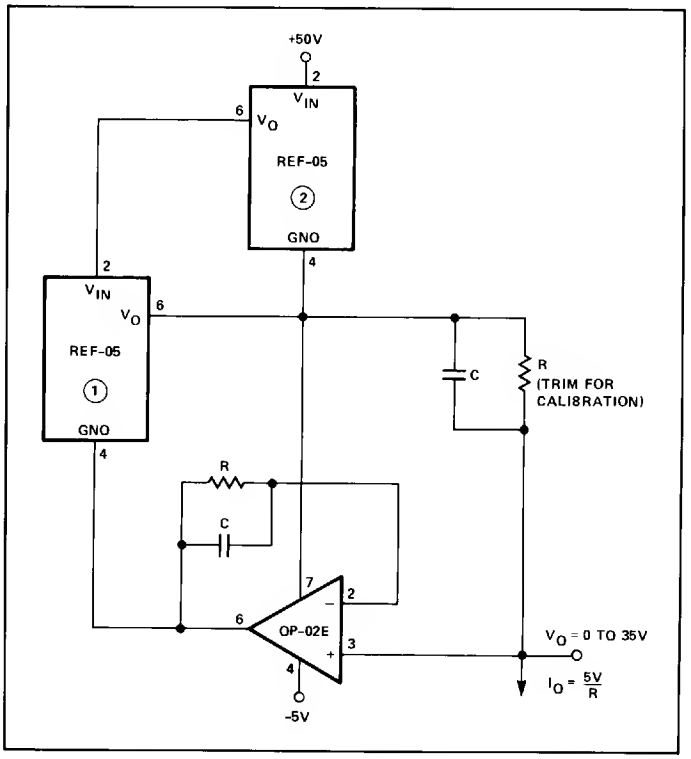
±2.5V REFERENCE



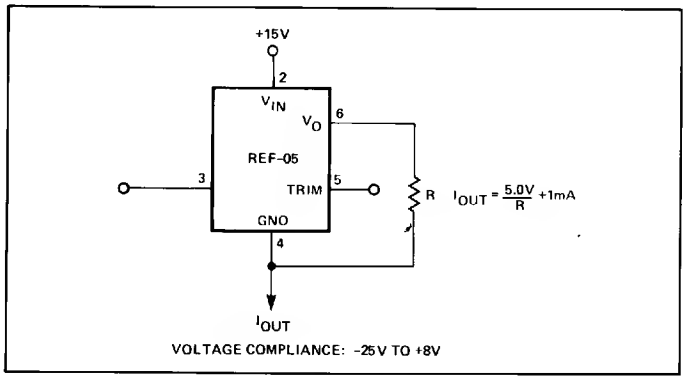
PRECISION CURRENT SOURCE

A current source with 35V output compliance and excellent output impedance can be obtained using this circuit. REF-05 (2) keeps the line voltage and power dissipation constant in device (1); the only important error consideration at room temperature is the negative supply rejection of the op amp. The typical 3μV/V PSRR of the OP-02E will create a 20ppm change (3μV/V × 35V/5V) in output current over a 35V range. For example, a 5mA current source can be built (R = 1kΩ) with 350MΩ output impedance.

$$R_O = \frac{35V}{20 \times 10^{-6} \times 5mA}$$



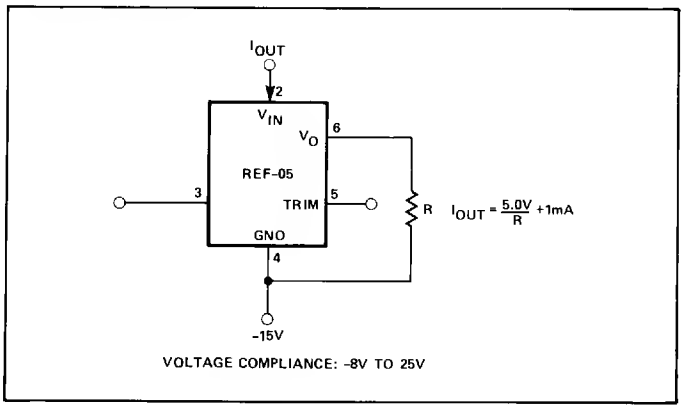
CURRENT SOURCE



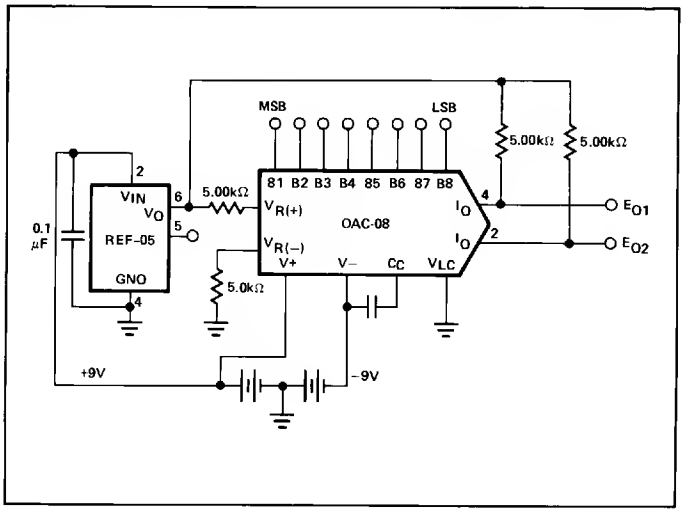
SUPPLY BYPASSING

For best results, it is recommended that the power supply pin is bypassed with a 0.1μF disc ceramic capacitor.

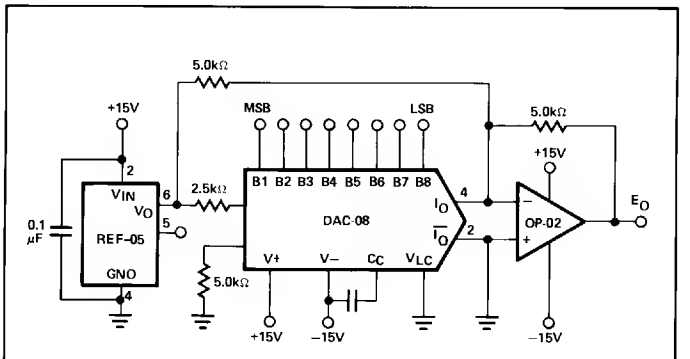
CURRENT SINK



BATTERY-OPERATED D/A CONVERTER REFERENCE



D/A CONVERTER REFERENCE



	B1	B2	B3	B4	B5	B6	B7	B8	E
POS. FULL-SCALE −1 LSB	1	1	1	1	1	1	1	1	+4.960
ZERO-SCALE	1	0	0	0	0	0	0	0	0.000
NEG. FULL-SCALE +1 LSB	0	0	0	0	0	0	0	1	−4.960
NEG. FULL-SCALE	0	0	0	0	0	0	0	0	−5.000